Chapter 42

Design of an ICT Tool for Decision Making in Social and Health Policies

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ABSTRACT

The governance requires technical support regarding the complexity in deciding health policies to assist people who require long-term care. Long-term care policies require the use of ICT simulation tools that can provide policy makers with the option of going into a decision theatre and virtually knowing the consequences of different policies prior to finally determining the real policy to be adopted. In this sense, there is an absence of simulation tools for decision making about long-term care policies. In this chapter, the authors propose the foundations and guidelines of SSIMSOWELL, a new scalable, multiagent simulation tool that increases the prediction capacity of governance in the long term care policies, improving the decision making in short, medium, and large term in different European regions. The simulation tool implements a previously validated Social Sustainability Model (SSM). The main goal of SSIMSOWELL is the prediction of policy impacts and the development of new governance models, since it increases the budgetary efficiency and the sustainability of long term policies. In addition, it improves the capacity of policy makers in modelling, planning, and evaluating social-health policies at different scales, ranges, and times in the European Union.

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INTRODUCTION

The European Commission has recognized the complexity in deciding health and social policies to assist people who require long-term care without knowing its consequences in the short, medium and long term (European Commission, 2003, 2008). The complexity of these decisions and policies requires the use of Information and Communication Technologies (ICT) simulation tools. These simulation tools can provide policy makers with the option of going into a decision theatre and virtually knowing the consequences of different policies prior to finally determining the real policy to be adopted. In this way, prediction of impacts of healthcare and social welfare policy measures would be greatly improved.

In order to develop ICT simulation tools for healthcare policies, a close collaboration between different research fields is necessary. On the one hand, a comprehensive and faithful model of the entire health and social welfare system is required. In this model, all the existing inputs should be taken into account, the relationships among, patients, health actors, health subsystems and performance outputs should be clearly defined, and the evolution over time of the required performance metrics should be quantified. On the other hand, a scalable simulation tool based on a distributed computer platform is required, in order to simulate the model of the health and social welfare system on population sizes and periods of time of different orders of magnitude.

Health and social welfare systems are complex adaptive systems where social and biophysical agents are interacting at multiple temporal and spatial scales (Janssen & Ostrom, 2006). The main challenge for the study of governance of these systems is improving our understanding of the conditions under which cooperative solutions are sustained, how social actors can make robust decisions in the face of uncertainty and how the topology of interactions between social and biophysical actors affect governance. Conventional approaches, based on empirical studies from laboratory experiments and fieldwork, do not explicitly include non-convex dynamics of ecosystems, non-random interactions of agents, incomplete understanding, or empirically based models of behaviour in collective actions. On the contrary, agent-based simulation addresses the previous features explicitly and is therefore potentially useful to address the current challenges in the study of governance of social-ecological systems. Therefore, multiagent based simulation systems seems to be the best strategy for developing a simulation tool for social welfare and health policies.

On the one hand, we have previously worked on developing a transitional theoretical model, named Social Sustainability Model (SSM) (Garcés, Ródenas, & Sanjosé, 2003); linked to health and social systems to address the issue of long-term care, as a way for overcome the complex problems which threaten sustainability of health and social welfare systems. (Commission of the European Communities, 2009; Guillén, 2010). On the other hand, we have previously worked on the development of scalable simulation tools based on distributed computing applied to fields such as crowd simulation (Vigueras, Orduña, Lozano, Chrysanthou, 2011; Vigueras, Lozano, & Orduña, 2010). Also, we have worked on mechanisms for social decision making applied to solve different problems such as meeting scheduling or urban mobility, all of them within the field of multiagent-based social simulation (Grimaldo, Lozano, & Barber, 2008; Grimaldo, Lozano, & Barber, 2010). Since the scalability of Multi-Agent Systems for simulating social behaviour of crowds of humans is still an open issue (CROSSROAD, n.d.; IMPACT, n.d.), it is necessary a careful design of the simulation tool, taking into account hardware and software architectures, in order to ensure the scalable simulation of the proposed model.

In this chapter, we propose the foundations and guidelines of a new scalable multiagent simulation tool (named SSIMSOWELL) for decision making in long-term care policies. SSIMSOWELL will provide the user with an overall evaluation of the social and economic sustainability of the changes in the social policies, the effects of these policies on citizen's quality of life and the citizen's social co-responsibility. In this sense, the complexity of decision-making in this field makes SSIMSOWELL a significant advance in the modelling and simulation of complex processes and simulation techniques, since the agent-based computer simulation has been never applied to social and welfare fields with the purpose of forecasting the results of different policies. The simulation tool will provide policy makers with different virtual scenarios (geographical and temporal) for analysing the impacts of different policies prior to determining the real policies to be adopted. The simulation results will improve the suitability of the health and social care facilities for citizens requiring long term care in Europe, and it will also improve the specific weight of citizen's preferences in the design of long term care policies, increasing the interaction of citizens with the government.

BACKGROUND

The foundations of a new scalable multiagent simulation tool for decision making in long-term care policies is based on three different fields: the healthcare and welfare transitional model, the multiagent-based social simulations and the scalable distributed computing for multiagent-based simulation.

Healthcare and Welfare Transitional Model

Technological and scientific advances in the 19th and 20th centuries in developed nations have led to an increase in life expectancy as well as to a variety of lifestyle- related diseases. This has produced a society with an unprecedented high share of elderly people and predominant (chronic) diseases (WHO, 2002). Elderly people are the group most affected by loss of functional capacity, as they suffer more from physical and mental deterioration and are more likely to suffer from chronic diseases, with associated multiple health problems (Grundy & Glaser, 2000; Singh, 2005).

The demographic dynamic of population aging (with a spectacular increase of life expectancy) and a low rate of economic growth of OECD economies constitute serious threats financial sustainability of pension and health systems, according to European Commission, Economic Policy Committee (2006). Moreover, in the following 15 years the state will have to face three problems: firstly, financial pressure of pensions on public expenditure due to massive retirements; secondly, there will not be a sufficiently mature and organized supply of socio-health services to deal with the demand. Thirdly, the health systems that were designed in the 1950s and 1960s cannot absorb the pressure of socio-health demands.

In the welfare states, the coordination between different social and health care resources is not as effective as expected covering the wide variety of needs of older dependent adults, and has indicated the lack of adaptation of supply and service planning to meet these needs (Carpenter, Challis, & Hirdes, 1999; Fine & Glendinning, 2005). The adjustments made as a result of proposals to reduce (or control) the public spending (Comas et al., 2006) have led to an absence of growth in the supply of public resources and a shift to private supply and/or family or informal care (Knapp, Hardy, & Forder, 2001).

Two of the most important systems of European public protection, social services and health systems, operate in parallel and in an uncoordinated manner with distinct assessment systems, distinct training and distinct professional cultures. This leads to ineffectiveness and inefficiency having a negative effect on the quality of life of its users and state budgets, which will be unable to stop public expenditure in these protection systems (Interlinks, 2008). Assuming the impossibility of resolving the problems presented within the present health and social model which has had its deficiencies patched, postponing a solution of its problems. Because of this, we need to design a new model, with a planning process to open up the transitional period. This transitional process will be tangible if we are able to imagine and implement from a socio-political point of view, different axiological bases and holistic methodological processes that moves towards the other stage.

The answer we propose to this complex problem is the restructuring of two systems of protection – social and health- with the finality of making them more efficient and effective. We suggest the application of the Social Sustainability Model (SSM) (Garcés, Ródenas, & Sanjosé, 2003) to the long-term care field. This transitional model, as promoted by Polibienestar Research Institute (University of Valencia), consists of a joint reorganization of the social services and the health system, as a holistic model providing an answer to the necessities of people requiring long-term care, to increase their welfare and quality of life, which includes dying with dignity. The model includes the criteria of sustainable health and social care: affordability, quality, appropriateness, and accessibility. The model is affordable and accessible because its implementation depends on the responsibility of the individual in using the system combined with the universal principle of welfare-state equity (also proposed as one of the ethical principles of sustainable health care by Jameton & McGuire 2002 as 'justice and equality: everyone should have reasonable access to adequate resources needed for healthfulness'). Batalden and Davidoff (2007) show that it is a model of quality because it has integral knowledge of individual necessities – social, health, functional, psychological, economic, and cultural – and providing an individualized method of planning and management of them. It is now an appropriate model as it refers to care that is tailored to the needs and cultural preferences of the clients.

In this context, it is necessary to develop tools to enable public administrations to make decisions, considering the long-term sustainability of the measures to be taken. These tools should be based on ICT, as demanded by the European Commission through the funding programs of research.

Multiagent-Based Social Simulation

Social-ecological systems are complex adaptive systems where social and biophysical agents are interacting at multiple temporal and spatial scales (Janssen & Ostrom, 2006). The main challenge for the study of governance of social-ecological systems is improving our understanding of the conditions under which cooperative solutions are sustained, how social actors can make robust decisions in the face of uncertainty and how the topology of interactions between social and biophysical actors affect governance. Conventional approaches, based on empirical studies from laboratory experiments and fieldwork, do not explicitly include non-convex dynamics of ecosystems, non-random interactions of agents, incomplete understanding, or empirically based models of behavior in collective actions. On the contrary, agent-based simulation addresses the previous features explicitly and is therefore potentially useful to address the current challenges in the study of governance of social-ecological systems.

A review of the literature (Hare & Deadman, 2008) has revealed many different terms being used to describe agent-based simulation. It is worth emphasizing two of them: the agent-based modelling described by Epstein and Axtell (1996) and multi-agent simulation (Gilbert & Troitzsch, 2005). There are two important conceptual distinctions in these approaches, coming from the different heritages of agent-based simulation. On the one hand, following Artificial Life, there is the belief that interactions are the most important phenomena to be modelled (agents can therefore be fairly simple in terms of cognition). Hence, agent-based modelling is used to discover fundamental local micro mechanisms that generate macro structure. On the other, according to the Distributed Artificial Intelligence and Multi-Agent Systems (MAS), deliberative social cognition is the most important (i.e. the deliberations of the agents spawn the interactions). Thus, multi-agent simulations refer to systems containing many agents, that are autonomous (they act independently from any controlling intelligence), social (they interact with other agents), communicative (they can communicate with other agents explicitly via some language), reactive (they observe and respond to changes in the environment), and pro-active (they are goaldriven [Wooldridge & Jennings, 1995]). The definition of Agent-Based Social Simulation (ABSS) in Doran (2001) is simply another term for a multi-agent simulation.

ABSS has been proposed as a suitable manner to tackle Social-Ecological systems (Janssen & Ostrom, 2006), Environmental Management (Hare & Deadman, 2008), Economics (Tesfatsion, 2006), Anthropology (Kohler, Gumerman, & Reynolds, 2005), and Ecology (Grimm, 1999). ABSS provides a framework for implementing techniques that fulfill the requirements of environmental modelling. First, ABSS allows to couple the model of the environment to the social entities that it includes. For example, it makes possible to model aspects such as the roles of social interaction and the disaggregated adaptive human decision-making; and second, it enables the study the relationships between the micro-macro levels of decision-making, and the emergence of collective behaviour as the response to changes in the environment or in the environmental management policies.

Social and organizational models are being studied in order to regulate the autonomy of self-interested agents. Nowadays, the performance of a MAS is determined not only by the degree of deliberativeness but also by the degree of sociability. In this sense, sociability points to the ability to communicate, cooperate, collaborate, form alliances, coalitions and teams. The assignment of individuals to an organization generally occurs in Human Societies (Prietula, Carley, & Gasser, 1998), where the organization can be considered as a set of behavioral constraints that agents adopt, e.g., by the role they play Dignum & Dignum (2001).

The definition of a proper MAS organization is not an easy task since it involves dealing with three dimensions: functioning, structure, and norms (Hübner, Sichman, & Boissier, 2007). From the functioning perspective, systems focus on achieving the best plans and cover aspects such as: the specification of global plans, the policies to allocate tasks to agents, the coordination of plans, etc. (Decker, 1998). From the structural perspective, systems focus on defining the organizational structures (roles, relations among roles, groups of roles, etc.) that establishes the obligations/permissions of their agents, as shown in Fox et al. (1998).

Social reasoning has been extensively studied in MAS in order to incorporate social actions to cognitive agents (Conte & Castelfranchi, 1995). As a result of these works, agent interaction models have evolved to social networks that try to imitate the social structures found in real life (Hexmoor, 2001). Social dependence networks allow agents to cooperate or to perform social exchanges attending to their dependence relations (Sichman & Demazeau, 2001). Trust networks can define different delegation strategies by means of representing the attitude towards the others through the use of some kind of trust model, e.g., the reputation shown in Falcone et al. (2004). Agents in preference networks express their preferences normally using utility functions so that personal attitudes can be represented by the differential utilitarian importance they place on the others' utilities. Following this preferential approach, we proposed the Multi-modal Agent Decision Making (MADeM) model (Grimaldo, Lozano, & Barber, 2008) as a market-based mechanism for social decision making (Chevaleyre et al., 2006), capable of simulating different kinds of social welfares (e.g. elitist, utilitarian), as well as social attitudes of their members (e.g. egoism, altruism). MADeM has been made available open-source as J-MADeM (Grimaldo, Lozano, & Barber, 2010), a full-fledge AgentSpeak(L) library (Rao, 1996) that implements the MADeM model in *Jason* (Bordini, Hübner, & Wooldrige, 2007), the well-known extended java based interpreter for this agent oriented programming language. The J-MADeM library provides agents with a general mechanism to make socially acceptable decisions, and it has been applied to better solve different problems such as meeting scheduling or urban mobility, as shown in Grimaldo, Lozano, and Barber (2010).

Scalable Distributed Computing for Multiagent-Based Simulations

Simulations based on multi-agent systems have been widespread used last years. The most extended type of multi-agent based simulations is crowd simulations, a special case of Virtual Environments (Singhal & Zyda, 1999) where the avatars are autonomous agents instead of user-driven entities. The simulation of large crowds of autonomous agents (crowd simulation) has become an essential tool for many virtual environment applications in education, training, and entertainment (Diller et al., 2004; Sung, Gleicher, & Chenney, 2004; Lozano et al., 2007). Crowd simulations model the motion of crowds and other flock-like groups as interacting particles that display different behaviours in 2D/3D scenes (Sims, 1990). Agent-based crowd simulations aim to capture the nature of a crowd as a collection of individuals, each of which can have their own goals, knowledge and behaviours (Reynolds, 1987). These applications require both rendering visually plausible images of the virtual world and managing the behaviour of autonomous agents at interactive rates. In this sense, crowd simulations are the kind of multi-agent systems imposing the hardest constraints on both the number of agents and the interactivity limits. As a result, the simulation of the realistic behaviour of large crowds of autonomous agents is still a challenge for several computer research communities. Therefore, we will assume the state of the art of crowd simulations as the milestone to be overcome.

The sum of graphical quality and realistic behaviour requirements in crowd simulations results in a computational cost that highly increases with the numbers of agents in the system. Therefore, crowd simulations require a scalable design that can handle simulations of large crowds in a feasible way. In this sense, some proposals tackle crowd simulations as a particle system with different levels of details (eg:\emph{impostors}) in order to reduce the computational cost (Tecchia, Loscos, & Chrysanthou, 2002). Also, there are purely graphic approaches like (Treuille, Cooper, & Popovic, 2006) that are not concerned with scalability problems because they are not focused on managing the behaviour of a high number of autonomous agents. Although these proposals can handle crowd dynamics and display populated interactive scenes (10000 virtual humans), they are not able to produce complex autonomous behaviours for their actors. Other proposals focus on providing efficient and autonomous behaviours to crowd simulations (Iglesias & Luengo, 2005). However, they are based on a centralized system architecture, and they can only control a few hundreds of autonomous agents with different skills (pedestrians with navigation and/or social behaviours for urban/evacuation contexts). Taking into account that pedestrians represent the slowest human actors (in contrast to other kind of actors like drivers in cars, for example) these results show that scalability has still to be solved in multi-agent crowd simulations.

The main problem is that the computational cost of multiagent crowd simulations exponentially increases with the number of agents in the system, requiring a scalable design that can support huge amounts of agents (of different orders of magnitude) by simply adding more hardware. In this sense, the use of distributed computer architectures has been already proposed for crowd simulations. A representative proposal has achieved that a PLAYSTATION-3 (IBM Cell Engine processor) can display a crowd composed of 15000-fishes at 60 frames per second (Reynolds, 2006). This work incorporates spatial hashing techniques and it also distributes the load among the IBM Cell Engine Synergistic Processor Elements (SPEs). The same social forces model has been also integrated in a PC-Cluster with MPI communications among the processors, although the number of simulated agents is still low (512 agents) and the execution times are far from interactive (Zhou & Zhou, 2004). Another work describes the use of a multicomputer with 11 processors to simulate a crowd of 10.000 agents at interactive rates (Quinn, Metoyer, & Hunter-Zaworski, 2003).

The use of many core processor architectures like Graphics Processing Unit (GPU) has also been proposed for enhancing the scalability of crowd simulations. For example, one work uses graphics hardware to simulate crowds of thousands individuals using models designed for gaseous phenomena (Courty & Musse, 2005). Recently, some authors have started to use GPU in an animation context (particle engine) (Peter, Mark, & Rudiger, 2004), and there are also some proposals for running simple stochastic agent simulations on GPUs (Perumalla & Aaby, 2008). However, these proposals are not suitable to simulate complex agents, including a cognitive model, at interactive rates.

Bleiweiss (2008) shows efficient GPU implementations of particle simulations or parallel global path finding using the CUDA programming environment. These works propose efficient models for a single GPU. The collision checking problem in crowd simulations has also been addressed by means of the GPU (Lauterbach et al., 2009), based on hierarchical data structures and sorting. However, the computational cost of these proposals was shown efficient to solve problems like ray tracing but not for agent based simulation.

In order to address the problem of scalability in crowd simulations, we proposed a distributed system architecture to tackle the requirements of interactive simulation of crowds of complex agents (Lozano et al., 2009; Vigueras, Lozano, & Orduña, 2010; Vigueras, Lozano, & Orduña, 2010b). That architecture consists of a distributed system where some of the computing nodes contain a distributed Action Server controlling the simulation. The rest of the computers host a set of agents implemented as threads of a single process. That architecture was shown efficient enough to support simulations up to tens of thousands of complex agents with plausible graphic quality. Later, this distributed scheme was improved by fully exploiting the potential of new manycore architectures like GPUs and a distributed visualization system (Vigueras, Orduña, Lozano, & Chrysanthou, 2011). As a result, a complete system capable of simulating tens of thousands of autonomous agents while visualizing different views of the virtual world at interactive rates was implemented. This implementation shows that the key issue in order to achieve a scalable simulation tool based on a multiagent system is to adapt the agents' software architecture to the distributed architecture of the underlying computer system.

THE SOCIAL SUSTAINABILITY MODEL

Using the technology described in the previous section, we intend to undertake the simulation of the transitional theoretical model called *Social Sustainability Model (SSM).* The main goal of the SSM is to optimise the suitability of present resources focusing on two objectives:

- Dependent persons must receive the necessary help with the maximum possible quality of life; the benefits of a certain action affecting health tend to be measured either in quantitative units (as is customary in Cost-Benefit Analysis) (Kuntz &Weinstein, 2001), or in qualitative units such as QUALY (Cost Efficiency Analysis) (Drummond et al., 2001).

- More persons must be attended when they need to be, which implies a redistribution of care resources among the potential users. This means that it is a case of designing a change in the care management system which raises the number of people benefiting from care, while total spending remains unchanged.

The first objective, referring to necessary, sufficient, and high quality services, implies studying the way in which certain services can be supplied at home when this is possible. The second objective implies management of the time care must last in each case, in such a way that resources needlessly occupied are freed up to attend more needy persons.

The first step to carry out this change consists of studying on one hand the way in which expensive resources can be replaced by other cheaper services, and on the other hand the ways in which services which are presently saturated can be freed up to attend more people. In EU we find this situation in hospital beds. With the aim of modelling the different care scenarios we shall concentrate our analysis on hospital facilities—the most expensive ones.

To illustrate the model, we select some hospital facilities in EU models such as the Hospitals for the chronically ill and long stay patient care (HCLS); the Short term stay medical units (STS), located in hospitals for the acutely ill, used to identify, evaluate and stabilise patients with a social and health care profile through the appropriate diagnosis and therapeutic instruments (frail elderly persons, the chronically ill, terminal patients, etc.), managing their assignment to the best therapy location; and the Units for Psychiatric Hospitalization (UPH), directed to provide intensive treatment under a continuous care regime in hospitals for the acutely ill.

For dependent patients using these hospitals we would evaluate the state of health, the functional dependence on other persons to carry out activities of daily life, and the existence or absence of a sufficient carer in the family sphere. These three aspects will be used afterwards to evaluate the possibility of assigning alternative care resources to patients currently being attended in hospital.

Our working hypothesis is that a careful study of the needs and possibilities of each patient can free up many hospital resources, through patient referral to other quality services, which provide fair and necessary care to dependent persons in their own home and social and family environment. Concretely: Among the patients admitted to specific hospital units—STS, HCLS, UPH—we will find persons with a suitable profile for referral.

The data sources available are: (1) the Data Bases and official records of the health and social public sectors, and (2) the data, from the field research, will be obtained through direct interviews from a sample of dependent persons in the different EU models. The first sources provide annual economic, medical and statistical data on every patient: gender, age, clinical diagnosis, number of stays (nights spent in hospital) for every patient and clinical circumstance entered; and also the total annual cost for each service, as well as the total annual number of stays. The second source enables us to assign alternative care resources for each patient with respect to their social-health profile.

For modelling the theoretical model, the care scenario we are proposing as an alternative means using home and community resources when the patient profile makes this possible, and also assisted nursing homes (with medical and more or less intense clinical care) when necessary. Concretely, the resources that we shall consider are: Home Help Service (HHS), Nursing Homes, Day Hospital (DH), Unit of Home Hospitalization (UHH), which from hospitals provide specialised health care in the home of the patient, after the period of stabilisation in hospital, and Primary Care (PC), (doctors, nurses, and social workers) at home.

Four indicators are taken into account to determine if dependent persons can or may not be attended in resources outside hospitals (or for referral of already admitted social and health care patients): (1) clinical complexity; (2) the degree of dependence in carrying out activities of daily life; (3) availability of a sufficient home carer to attend their needs; (4) age (60 years is the legal age limit to gain access to certain resources such as nursing homes).

Taking this into consideration, we assume the derivation criteria listed in Table 1 for non-psychiatric and psychiatric patients respectively.

Being a 'sufficient caregiver' for dependent mental patients implies that the caregiver does not work out of the patient's home. Independent patients presenting low clinical complexity do not need a family caregiver (Polibienestar, University of Valencia, 2010).

In some cases we will demand that the domestic carer is not in a job outside the patient's home owing to the permanent care the dependent person requires, whether it be due to their illness (psychiatric patients), their clinical complexity (patients attended by UHH), or their high dependence. Three standard levels of intensity are considered in HHS, whether domestic or personal: Low intensity (6hr/week); Medium intensity (10hr/week); High intensity (15hr/week).

A preliminar study performed with real data shows the potential saving that the model can offer. The results of this study are shown in Table

Table 1. Derivation criteria

1. Non-psychiatric patients (from STS and HCLS)		
Sufficient Carer		
Dependence for BADL	**Clinical Complexity: Low**	**Clinical Complexity: Medium**
Independence	Not needed /D-LI [1] + PC	D-LI/MI [1]+ DH
Low Dependence	D-LI/MI [1]+ PC	D-MI/HI [1]+ DH
High Dependence	P-LI (+DC) + PC	P-MI + DH
No Carer		
Dependence for BADL	**Clinical Complexity: Low**	**Clinical Complexity: Medium**
Independence	D-LI/HI [1]+ PC	D-MI/HI [1]+ DH
Low Dependence	P-LI/HI [1]+ PC	P-MI/HI [1]+ DH
High Dependence	Hospital (to 60y)/NH (over 60y)-LI	Hospital (to 60y)/NH (over 60y)-MI
2. Psychiatric patients (from UPH)		
Sufficient Carer [2]		
Dependence for IADL	Clinical Complexity: Low	Clinical Complexity: Medium
Independence	P-LI + MHU	P-MI + DH
Low Dependence	P-MI + MHU	P-MI + DH
High Dependence	P-HI + MHU	P-HI + DH
No Carer		
Dependence for IADL	**Clinical Complexity: Low**	**Clinical Complexity: Medium**
Independence	P-LI + MHU	UPH
Low/High Dependence	UPH	UPH

Notes. BADL: Basic activities of daily life. IADL: Instrumental activities of daily life. D: Domestic services; P: Personal and domestic services; LI=Low intensity (6h/week); MI=Medium intensity (10h/week); HI=High intensity (15h/week). PC: Primary Care; DH: Day Hospital; UHH: Unit for Home Hospitalization; MHU.= Mental Health Unit; NH: Nursing Homes. In Nursing Homes: LI/MI/HI= Degrees of medical care. [1]The intensity depends on whether the caregiver works out of the home or not, and whether the level of the patient's autonomy is high or low for instrumental activities of daily life'.

2. This table shows in the first rows the results extracted from current real data. The next rows show the potential effects that the model could have on a given scenario. This scenario considers a reduction of 10% of the average time of stay in each hospital unit. Using this scenario as a base, the benefits can be calculated for the percentages of reduction of the average stays. It could be that for every 10% reduction in the average number of hospital stays of dependent people, 4% more could be attended without any additional cost. Of course, there is a theoretical limit in the possible reduction of the average stay, which would be very important to estimate, and that can only be done from the management of socio-health resources.

THE SIMULATION TOOL

This section gives an overview of the simulation tool that has been designed to implement the Social Sustainability Model (SSM) presented in the previous section. As shown in Figure 1, the proposed simulation system is based on three main layers, dealing with: visualization, behavioral simulation and the underlying computer architecture.

At the top of the simulation tool, the visualization layer addresses the problems related to efficiently visualizing large datasets. Typically, it includes all the graphic interfaces required by policy decision makers to visualize the temporal evolution of the simulated parameters. These parameters can be categorized into two groups: microscopic and macroscopic indicators. The first group is devoted to analyze the behavior of a specific agent, service or resource (e.g. the usage patterns of a dialysis machine at a certain hospital). On the other hand, macroscopic indicators refer to the simulated population as a whole. Thus, they allow the visualization of global metrics such as sustainability, social welfare, quality of life, etc. Depending on the nature of the parameter being visualized, either its values will be reported during the simulation or they will be computed when the simulation is finished.

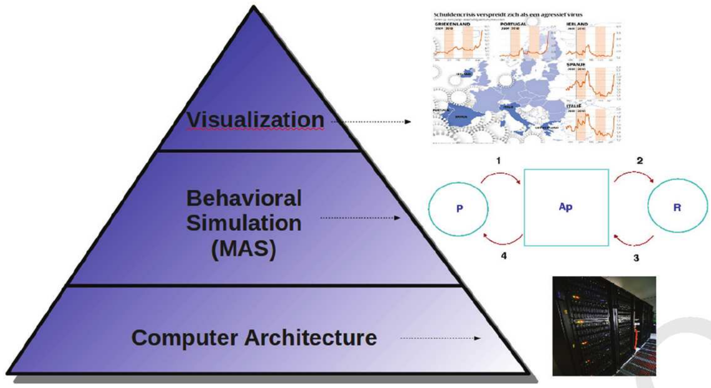
The visualization layer gets the data from the behavioral simulation layer. This layer has been designed following a multiagent approach, suitable to simulate the interaction scenarios required by the social sustainability model. Multiagent Systems (MAS) are an adequate computational formalism for modelling individual behaviours and, provided

Table 2. Cost of the alternative care proposal and saving. Number of extra dependent persons who could be attended in hospitals at the present cost and with the current length of stay (year 2004)

Scenarios		**Short Term Stay**	**Hospital for the Chronically ill and Long term Stay**	**Units for Psychiatric Hospitalisation**	**Total**
Present	*Average stay*	4,70	26,70	42,30	-
	Total Cost (Euros/year)	8.312.180,29	17.191.564,16	7.219.248,85	32.722.993,30
Scenario	*Average stay reduced by 10%*	4,23	24,03	38,07	-
	SAVING (Euros/year)	289.014,00	760.534,81	963.375,77	2.012.924,59
	Total cost (Euros/year)	8.023.166,29	16.431.029,35	6.255.873,08	30.710.068,71
	Number of extra dependent persons who could be attended (year)	270	192	96	558
	% extra versus total dependent persons attended (year)	3,48%	4,42%	7,02%	4,14%

Source: Polibienestar, University of Valencia, 2010.

Figure 1. Overview of the simulation tool

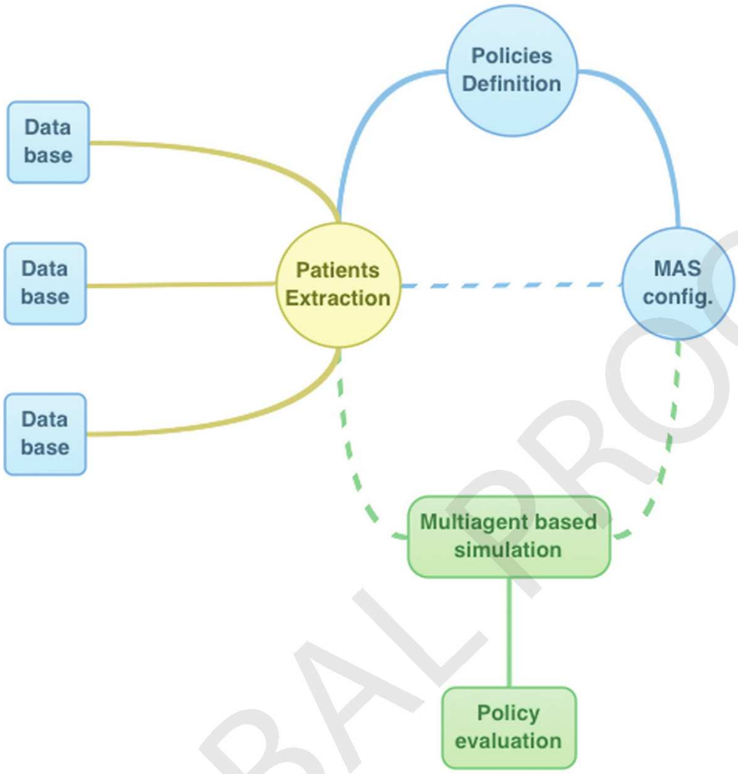


they are properly scaled, they can also simulate big populations. Therefore, the visualization layer needs to regulate the data captured from the MAS according to the required scale. This goal is achieved through frustrum culling techniques that computes the size of the image to be rendered according to the projection of the camera plane (denoted as MBR Frustum). These techniques can be performed either in the CPU or in the GPU, if that hardware allows it (Park, 2009). In turn, the MAS located within the behavioral simulation layer models the environment, the entities that populate it and all possible interactions amongst them. Each actor playing a role in a certain scenario is represented by an agent, then including entities such as patients, health managers and resources. For all of them, the level of description has to be chosen, which may range from a simple list of attributes to a fully-fledged cognitive architecture (e. g. Belief, Desires, and Intentions or BDI). These complex agent models will include cognitive artifacts such as trust, (institutional) reputation, and responsibility. Hence, these agents will also be able to perform evaluations of the services offered from their particular point of view (i. e. stakeholder evaluation), that could then be collected by the resources responsible for it.

Figure 2 depicts the main modules present in the behavioral animation layer. Patient extraction is the first step in the path leading to ensure a correspondence between the model and the real world. This module extracts the set of target patients whose age, health, and/or social status makes them require some kind of care from the social health system. That is, it selects those patients in the population or geographical area being considered that fulfill certain conditions (maybe as a result of external events such as accidents, acute illness, etc.). As well as depending on the demographic features of the population considered, this set dynamically varies along the time. The selection will be made by accessing specific social and health institutional databases and/or performing statistical studies with existing sample studies. The information (raw data) gathered from different types of data bases will be processed to obtain the features array for each patient and feed the simulation system.

The module Policies Definition is focused on the administration processes that govern the behavior of the agents representing health managers and health resources. The set of rules (derivation criteria) previously studied in the SSM contains the knowledge that this module applies to the policy definition. This process itself provides some recommendations about the socio-health resources needed by the patient. Since each policy essentially refers to a given target population, a different set of patients should be extracted depending on the policy to be simulated. Besides,

Figure 2. Main modules present in the behavioral animation layer



the limits and sizes of the populations and the periods considered should be outlined, in order to define the scalability criterion to be used. As a result, the problem size (i.e. number of patients, number, and types of policies, period of time for each one of this policies...) is defined.

Finally, as represented by the bottom layer in Figure 1, the simulation tool leans on a scalable distributed computing system devoted to efficiently support the computational loads generated by the previous layers. This system provides a pervasive layer spanning all other simulator features that will encompass a scalable distributed computing platform, a scalable design of agents, and a distributed visualization system. In this sense, it provides a common ground in which all other proposed processes and subsystems will be finally integrated. Different technological alternatives need to be analyzed as computer platforms (e.g. distributed, multi-core and many-core architectures, etc.). Moreover, the design of adaptive workload balancing techniques will be one of the key ingredients of this layer. Meta-heuristics and computational intelligence methods adapted to this particular problem should be developed in this layer. They will be necessary for assessing the efficient simulation of the SSM when applied on huge populations for long periods of time.

The validation of the SSIMSOWELL tool should include the performance evaluation of both, the computer architecture and the system architecture. It will require to perform real tests of different policies in different application domains as benchmarks for testing the whole functionality and the accuracy of the tool developed.

FUTURE RESEARCH DIRECTIONS

The topic discussed in this chapter refer to the development of advanced ICT tools for policy modelling, prediction of policy impacts, development of new governance models and collaborative solving of complex societal problems. The work in this area should advance research in simulation and visualisation techniques, process modelling, gaming, and mixed reality technologies while building on Web2.0/Web3.0, social networking, crowd sourcing and dynamics methodology techniques.

The SSM proves the need of restructuring social assistance and health systems in Europe, as shown in Garcés, Ródenas, and Sanjosé (2003, 2004), and Ródenas et al. (2008). The tool will simulate the SSM, which is a holistic model of attention to people that need long term care to increase their welfare and quality of life, which includes dying with dignity (according to Garcés, 2000), by a joint reorganization of health and social systems to provide an answer to the necessities of people requiring long term care. The innovation of the SSM consists of both:

1. The intersystem coordination that creates a unique portfolio of services. This portfolio integrates social and health resources that previously operated separately.
2. The improvement of the system with new methodological and technical capacities that operate the model, by combining: (1) the interdisciplinary coordination of professional human resource organization in decision making on the use of the services portfolio by case management; (2) using internationally standardized tools of evaluation and intervention in real time such as Resident Assessment Instrument (RAI) with unifying inter-professional criteria and protocols which create assistance itineraries, that cross the boundaries between the social and health systems, based on criteria of maximum efficiency for the welfare of the user; (3) Applying a socio-technical process by constructing socio-mathematical models of prediction of individual itineraries and its repercussions on the evolution of the entire health system in real time.

In this chapter, we have discussed about a multiagent-based simulation tool devoted to study the effects of applying a sustainable social and health care model (SSM) to health care and welfare policies. This advanced ICT simulation tool will be a multiagent-based social simulation system that includes the decision mechanism developed in the J-MADeM library (Grimaldo, Lozano, & Barber, 2010). This decision mechanism will allow the agents in the simulation tool to efficiently solve complex societal decision problems, in such a way that the simulator will be able to model huge population sizes.

Also, with the proposed tool we plan to use the knowledge acquired in the field of scalable distributed computing for designing truly scalable multiagent-based simulation tool. The implementation of a scalable distributed computing system will allow the efficient simulation and visualization of millions of complex autonomous agents. In this way, this multiagent system will be capable of simulating the SSM at the different orders of magnitude that the different geographical pilots can require (from local populations of thousands of people to regional health care and welfare systems of millions of people) by simply adding more hardware. Since we count on an SME partner that can provide the required hardware facilities and architectures, we can ensure that we will reach new limits in the size of multiagent simulations.

CONCLUSION

In this chapter, we have proposed the foundations of a simulation tool (SSIMSOWELL) that can provide policy makers with the option of going into a decision theatre prior to finally determining the long term care policy, improving prediction of impacts of health care and social welfare policy measures. This tool will help to modelling policies and to predict policy impacts. Also, it will help in the development of new governance models and collaborative solving of complex societal problems, as the sustainability of social and health care systems.

Since there are different social protection systems in Europe, we have proposed on the one hand the SSM as a theoretical model, which could be adapted to other European social protection systems. On the other hand, SSIMSOWELL will become a scalable simulation tool based on a distributed multiagent system that is simulated on a distributed computer system. Both systems will be designed and implemented focusing on scalability, in such a way that the simulation tool will be able to simulate different policies applied to population sizes and periods of time of different orders of magnitude, ranging from local to regional health systems and populations, from some months to tens of years.

The simulation tool will increase the engagement of citizens in the health and social care policies, by means of taking into account the citizen's preferences in the use of health and social resources network, as the inputs of the model. In order to achieve this goal, the simulation tool will access to public institutions databases across the regions of European Union.

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